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SURVEILLANCE SYSTEMS TEST AND EVALUATION FACILITIES

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ABSTRACT

In January of 1983, a team was formed by AEDC to explore test methodologies and test facility concepts required to meet the needs of future space-based surveillance systems. This team was composed of members from the Air Force and Calspan/AEDC Division and involved a contract with the Ralph M. Parsons Company who subcontracted to TRW Space and Technology Group, JAYCOR, Pittsburgh Des Moines Corporation, and Cryogenic Vacuum Incorporated. The output of this study was a road map of test methodologies and test facilities that will aid the development of this country's critical space-based sensor assets. This paper is a condensation of those results.

INTRODUCTION

In May of 1984 the Air Force Systems Command designated AEDC as the Center of Expertise for space environment-simulation testing. In this capacity, the Center is to provide the test and evaluation expertise in several assigned functional areas, including space sensors. The test and evaluation of such systems is particularly challenging when one considers that they must be able to operate in a thermonuclear environment against extremely large numbers of targets. This presents a unique problem for the test and evaluation of such systems. For example, in the development cycle for a new aircraft, engines and airframes are first thoroughly ground tested; then the assembled aircraft is subjected to an extensive flight test program. This eventually includes intensive operational testing prior to theater deployment.

Certainly no one would recommend going directly from component ground test to system deployment. The situation that faces the space-based sensor developer is an inability to test his system in orbit against a realistic attack scenario including the thermonuclear environment. This means that the "flight and operational" testing must be performed in ground test facilities. The simplistic approach to adequate ground testing is to try to simultaneously capture the entire operational scenario in a ground test environment. This is analogous to a flight of a full-scale aircraft in a wind tunnel at the proper altitude, air temperature, Mach and Reynolds numbers. The test methodology that has developed in the ground testing of spacecraft has shown that there are ways to "take the problem apart," i.e., determine where to substitute simulation for duplication and still obtain useful data. This development of a test methodology in the space-based sensor arena is presently in the early stages. The following paragraphs outline an approach which addresses some of the applicable methodology issues and the test facilities that result.

PERFORMANCE TESTING LEVELS

Although a space-based surveillance satellite has many components, the prime focus of this paper is the surveillance sensor. It can be divided into four major

elements: the focal plane array, cryocooler, signal processor, and telescope (see Fig. 1). The initial performance level test deals strictly with the focal plane array and progresses to the entire payload.

FOCAL PLANE ARRAY (FPA) LEVEL

The first level of testing to be performed on the sensor involves the FPA. There are three discrete parts to this level of testing: functional validation, characterization with a single point source, and characterization with a dual point source.

FPA Functional Validation

The goals of this level of FPA testing are to establish a common Air Force FPA test facility to eliminate differences among basic focal plane evaluations performed in the manufacturers' plants. Simple, flooded, focal plane testing will be conducted from 10^{-16} to 10^{-10} W/pixel in AEDC's Component Checkout Chamber (C³) as shown in Fig. 2. The C³ is a 1.2-meter-diameter bell jar and will be configured with a retractable mount for the focal plane to ensure a high test article throughput. The variable intensity blackbody source was developed by AEDC and has been calibrated by the National Bureau of Standards. The data from such tests will be computer-based for ease of access and analysis.

FPA Characterization with Single Point Source

The FPAs that show promise after the functional validation phase of testing will be tested at this level with blackbody flooding and the use of a single point source (see Fig. 3). At this level the FPA response to a simulated target and background can be evaluated along with spectral discrimination and crosstalk. Six orders of magnitude will again be available for the single point source. The point source will be scanned over the FPA through a combination of mirror and blackbody source motions controlled remotely during the test.

FPA Characterization with Dual Point Source

Again, the best FPAs from the previous test will be advanced to the dual target testing. At this point, through the use of beam splitter or dual projector technology, two targets will be provided to the FPA (see Fig. 4). Each will be controllable for conducting target tracking/crossing studies. All of the above tests are envisioned as being conducted with the FPA cooled by the test facility refrigeration machines. The next level of testing includes the flight cryocoolers.

FOCAL PLANE ARRAY/CRYOCOOLER LEVEL

At this point, the FPA has been tested as much as practical as a single unit. The major issues now involve the interface problems between the FPA and flight cryocooler, i.e., vibration, thermal uniformity, and thermal switching. Some of the

tests previously performed in the C³ will be repeated with the flight cryocooler in place of the facility refrigeration devices. Basic cryocooler life testing, requiring only vacuum conditions, can be performed in the 2- by 2-meter chamber shown in Fig. 5.

FPA/CRYOCOOLER/SIGNAL PROCESSOR LEVEL

At this level, the addition of the signal processor requires the testing of ability to interpret complex scenes, i.e., more than two targets. Such tests will be performed to investigate the system's ability to discriminate among targets as well as perform kill assessments. This can be accomplished using relatively small chamber optics due to the absence of the sensor telescope (see Fig. 6). This test methodology makes use of projection rather than solid-state technology to produce the complex scene. AEDC has carried out extensive studies in the area of scene generation, and we believe the most promising techniques for producing Long Wave Infrared (LWIR) scenes to be solid-state thermal emitters and projection systems using scanning mirrors.

The basic advantage of solid-state scene generation is the potential for large numbers of targets. However, this technology is still developmental and may have serious limitations in providing wide dynamic range and spectral fidelity.

AEDC has used direct projection of targets from blackbody sources rather successfully in our aerospace chamber 7V. This technology is being improved through the use of mixing/integrating spheres to produce spectrally accurate targets for use in discrimination/kill assessment testing. AEDC is also developing a mechanical mirror scanning system designed to project spectrally accurate, blackbody targets in a cryogenic environment. Modules of four independently controllable target generators are in the prototype stages and are undergoing test at AEDC. Groups of these projectors may be assembled as shown in Fig. 7 to produce large numbers of targets.

The methodology and test facilities required to evaluate space sensor hardness has also been investigated at the Center. Although this topic is the subject for another paper, the results of our work have indicated the need for pilot X-ray and large X-ray test facilities for evaluating the hardness of the FPA/cryocooler/signal processor combinations (see Figs. 8 and 9). These facilities would be capable of producing full-threat-level-X-ray fluence levels and dose rates of the appropriate spectra to evaluate sensor performance.

FPA/CRYOCOOLER/SIGNAL PROCESSOR/TELESCOPE

Finally, the sensor will be fully assembled and tested for optical performance through the addition of the satellite telescope. At this level of testing, the sensor aperture diameter sizes the facility. The broad categories for sensor testing at this level are optical alignment, focus, radiometric throughput, and off-axis rejection (OAR). AEDC has performed sensor performance testing at this level in the aerospace chamber 7V for sensors with entrance aperture sizes less than one-half-meter diameter. OAR testing for sensors of the same class are carried out in the Mark I aerospace chamber as shown in Fig. 10.

One-Meter-Class Sensors

For sensors with entrance apertures in the one-meter class, the Mark I aerospace chamber would have to be modified as shown in Fig. 11 with the addition of a 20-K cryoliner, cryo-optics, and source generation device to conduct performance testing. Traditional OAR testing for sensors of this class will require either very large facilities or the use of a new test methodology. One such OAR methodology is under investigation at AEDC. The traditional OAR testing is conducted in such a manner that the length of the required test facility is a function of the test article entrance aperture and the OAR angle (see Fig. 12). This results in unacceptable facility sizes for sensors in the one-meter class. An alternate approach would be to map the sensor entrance aperture with a collimated test beam (see Fig. 13). This technique decouples the facility length from the test article entrance diameter. Such a technique will allow OAR testing of one-meter-class sensors in the Mark I chamber.

2- to 3-Meter-Class Sensors

Finally, as sensors move into the 2- to 3-meter entrance aperture range, a new facility will be required. The concept definition of this facility was the primary focus of the Center's contract with the Ralph M. Parsons Company. The facility is conceived as being a very large vacuum chamber (40 meters in diameter by 65 meters long) in which is mounted a high-performance optical bench. This facility would include cryopanel modules capable of rapid buildup/removal to ensure maximum facility flexibility with minimum operating costs. Figure 14 shows the SPACE facility configuration for OAR and mission performance of 2- to 3-meter-class space-based sensors. The dual antechamber design and multiple buildup bays ensure the maximum throughput for the facility; i.e., the tests are built up on carts and then injected into the facility. This facility will become a part of the AEDC space test complex as a national asset.

CONCLUSION

AEDC is continuing to update and modify plans to provide required test support in the space-based sensor arena. This country's future may well hinge upon our present and future role in space, and AEDC will continue to develop the test methodologies and facilities required to take us there successfully.

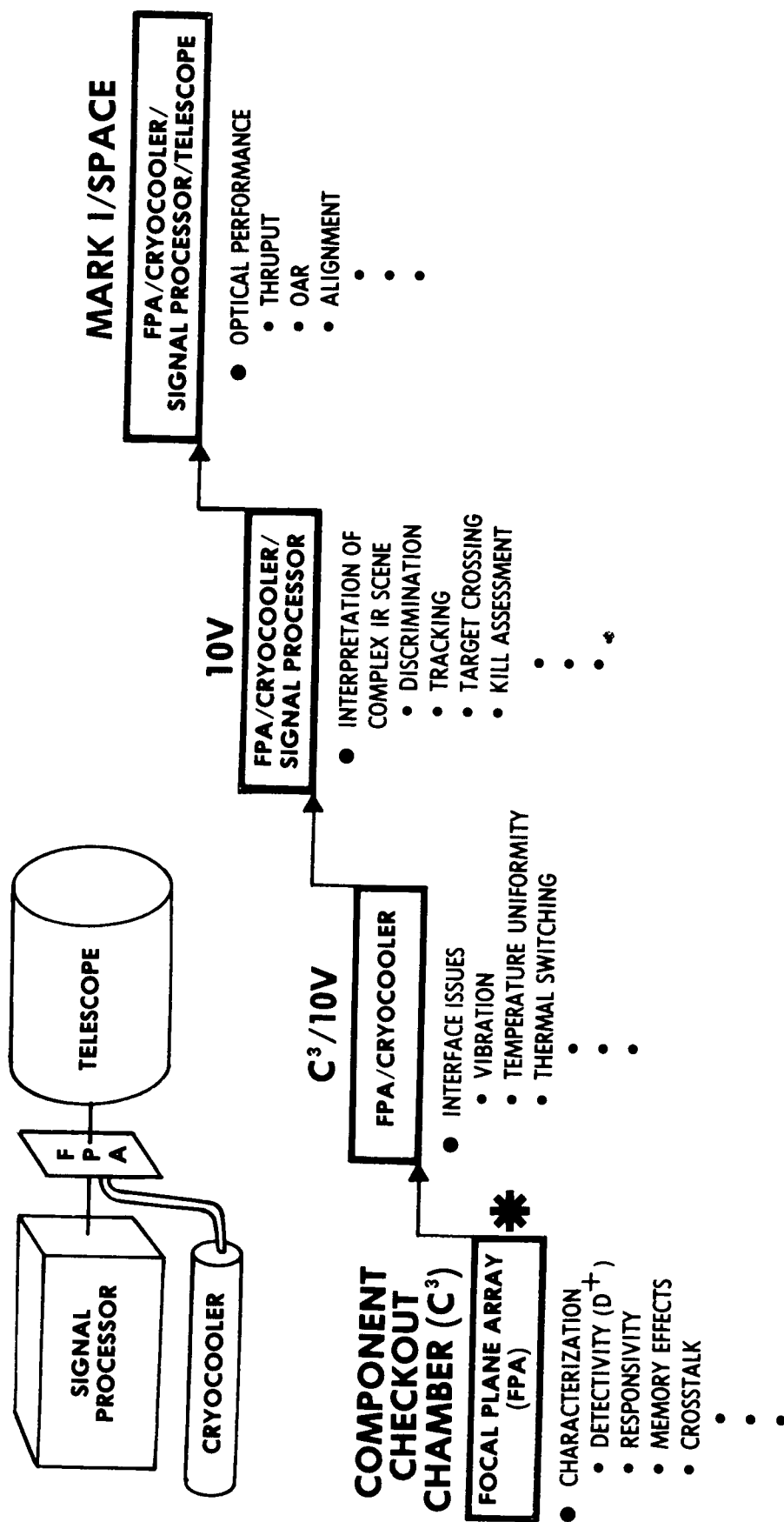


Figure 1. Surveillance system performance testing levels

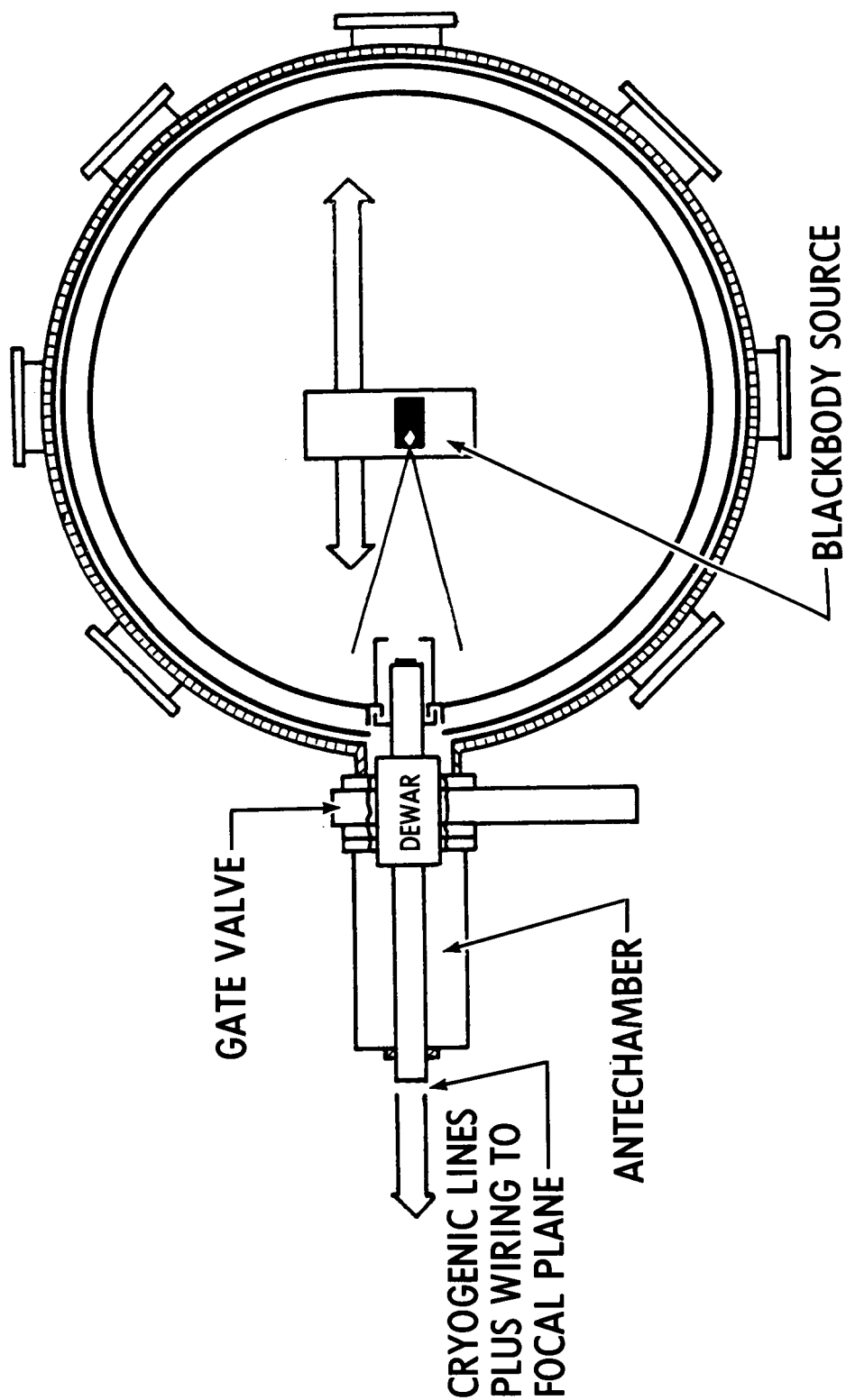


Figure 2. FPA functional validation test in AEDC component checkout chamber

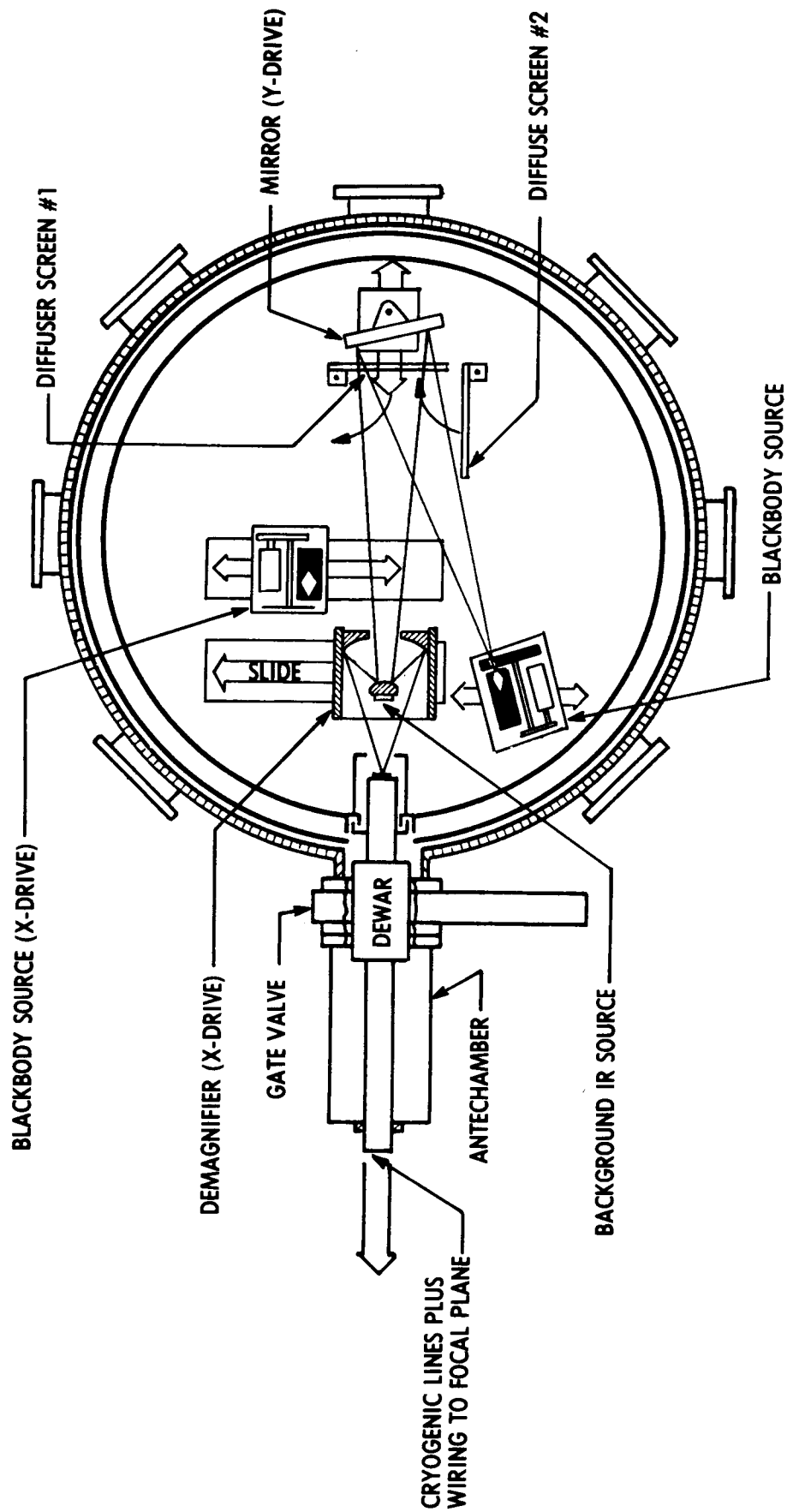


Figure 3. FPA characterization with single point source in AEDC component checkout chamber

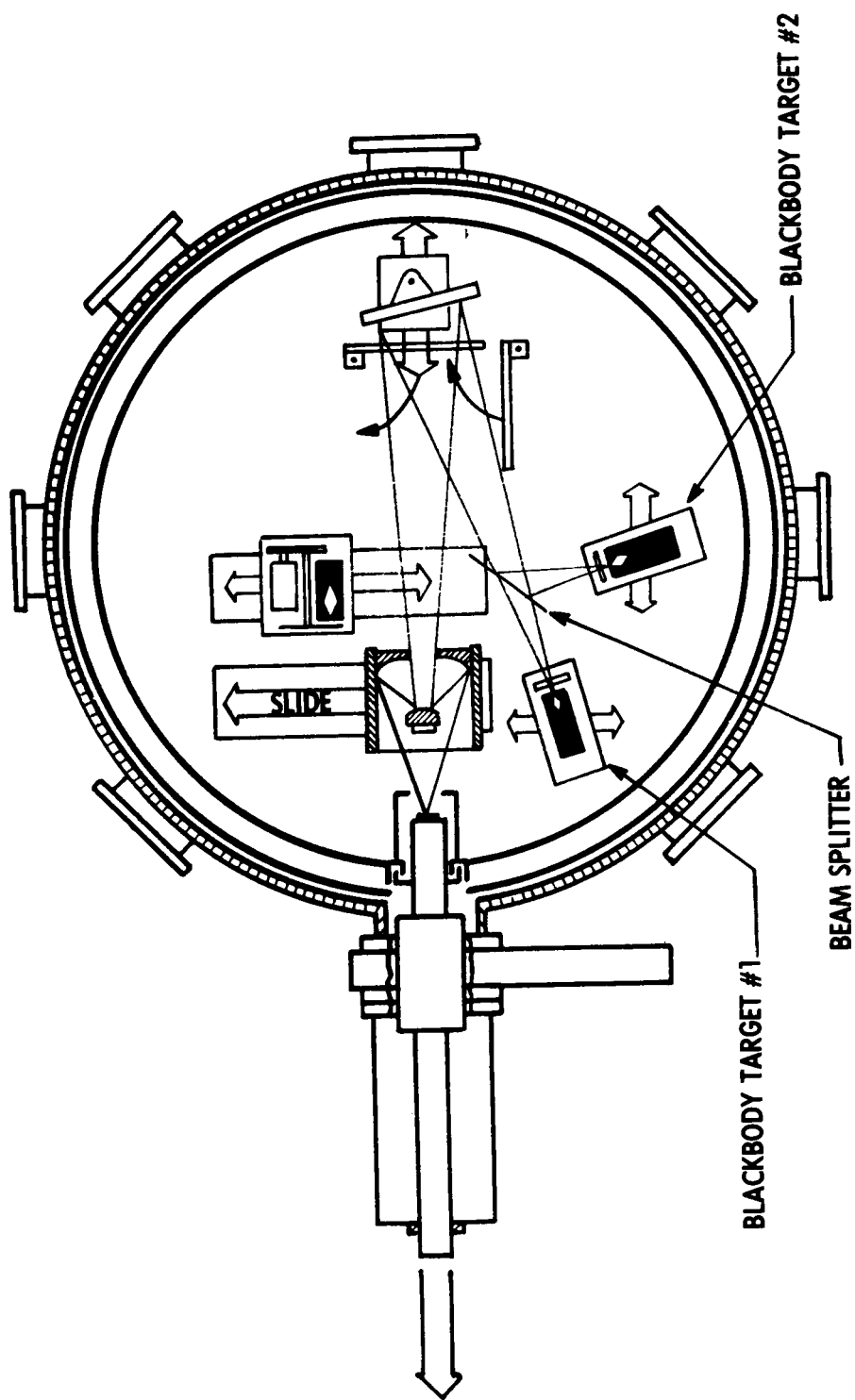


Figure 4. FPA characterization with dual point source in AEDC component checkout chamber

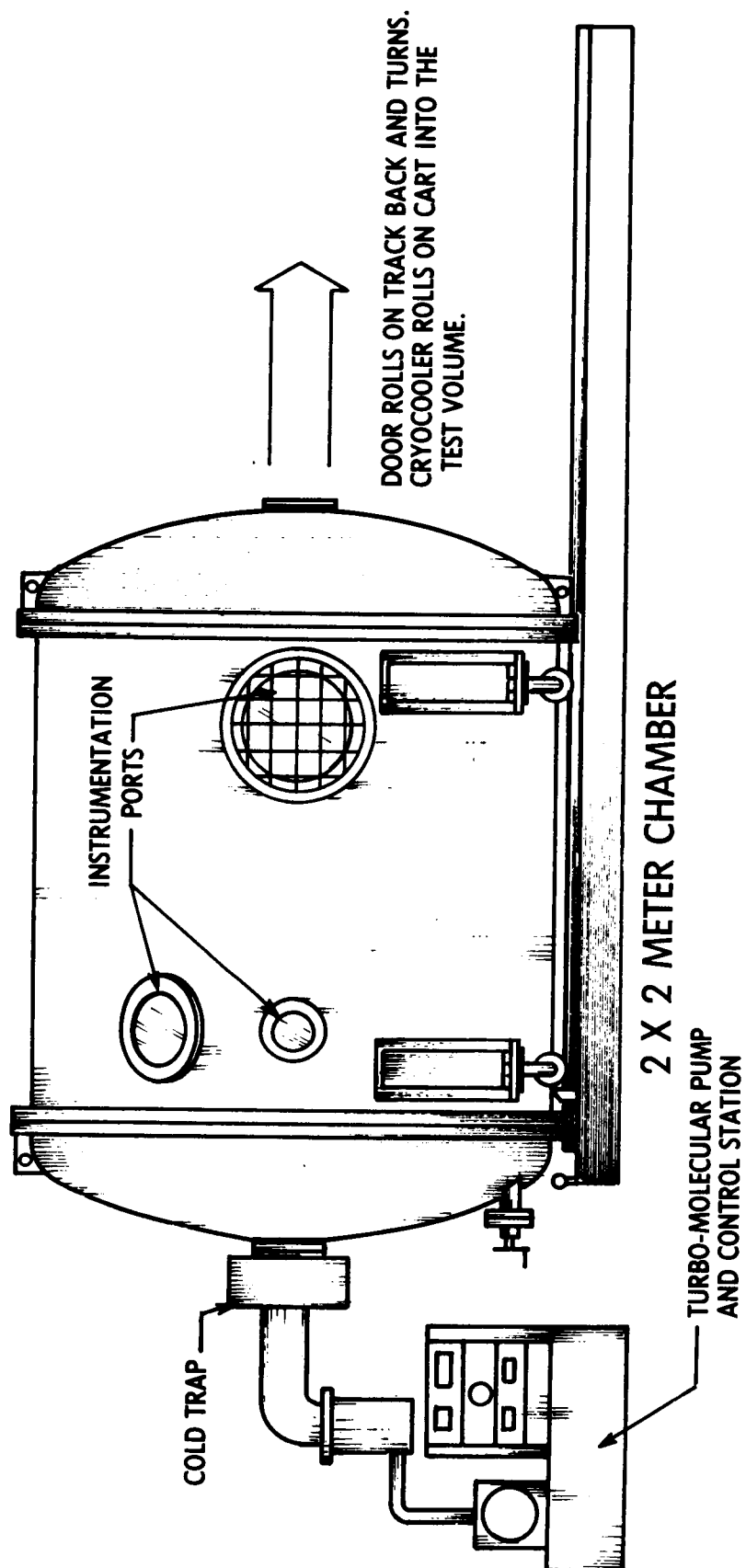


Figure 5. Sensor cryocooler life testing at AEDC

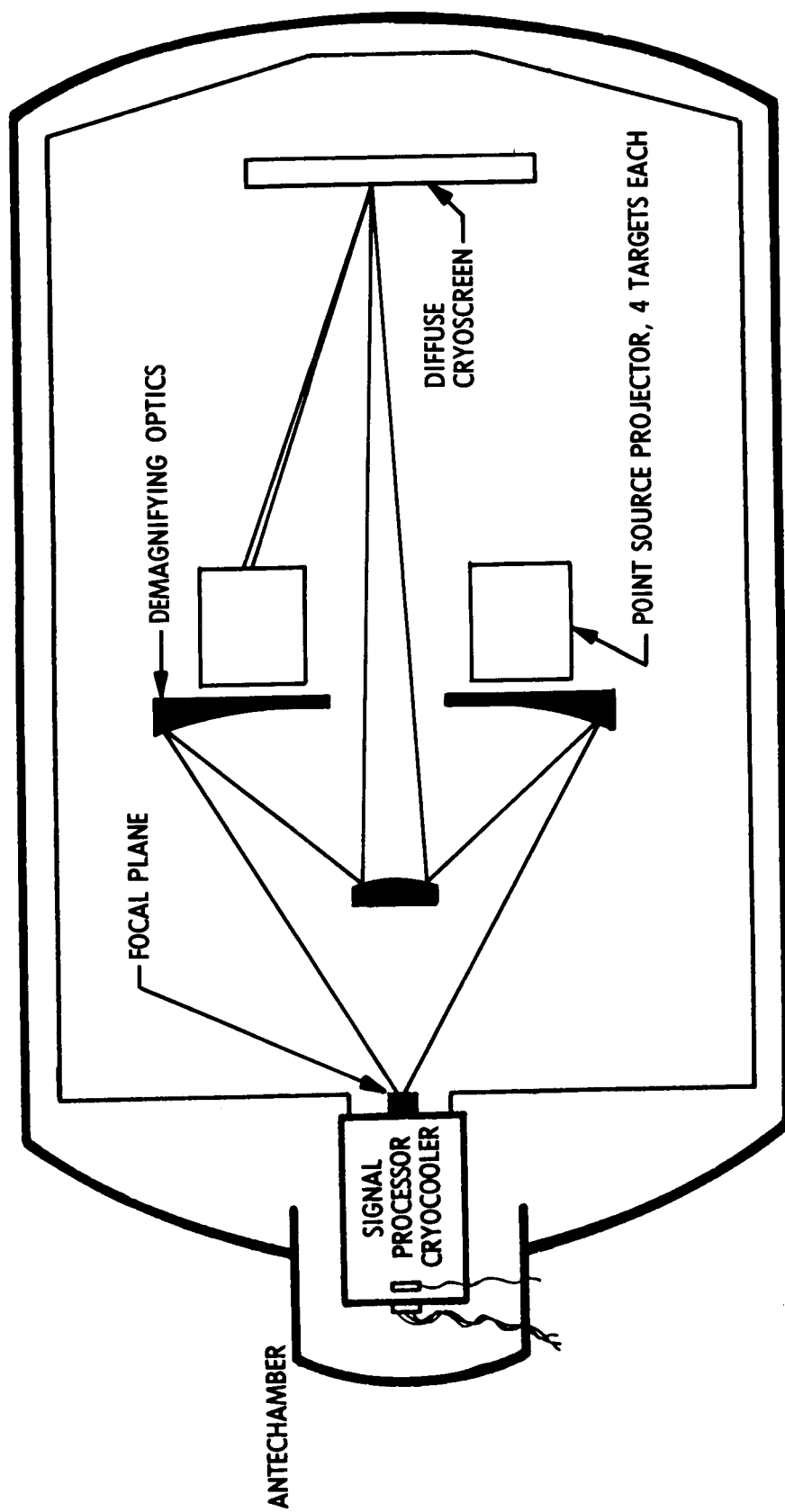


Figure 6. Complex scene projection layout

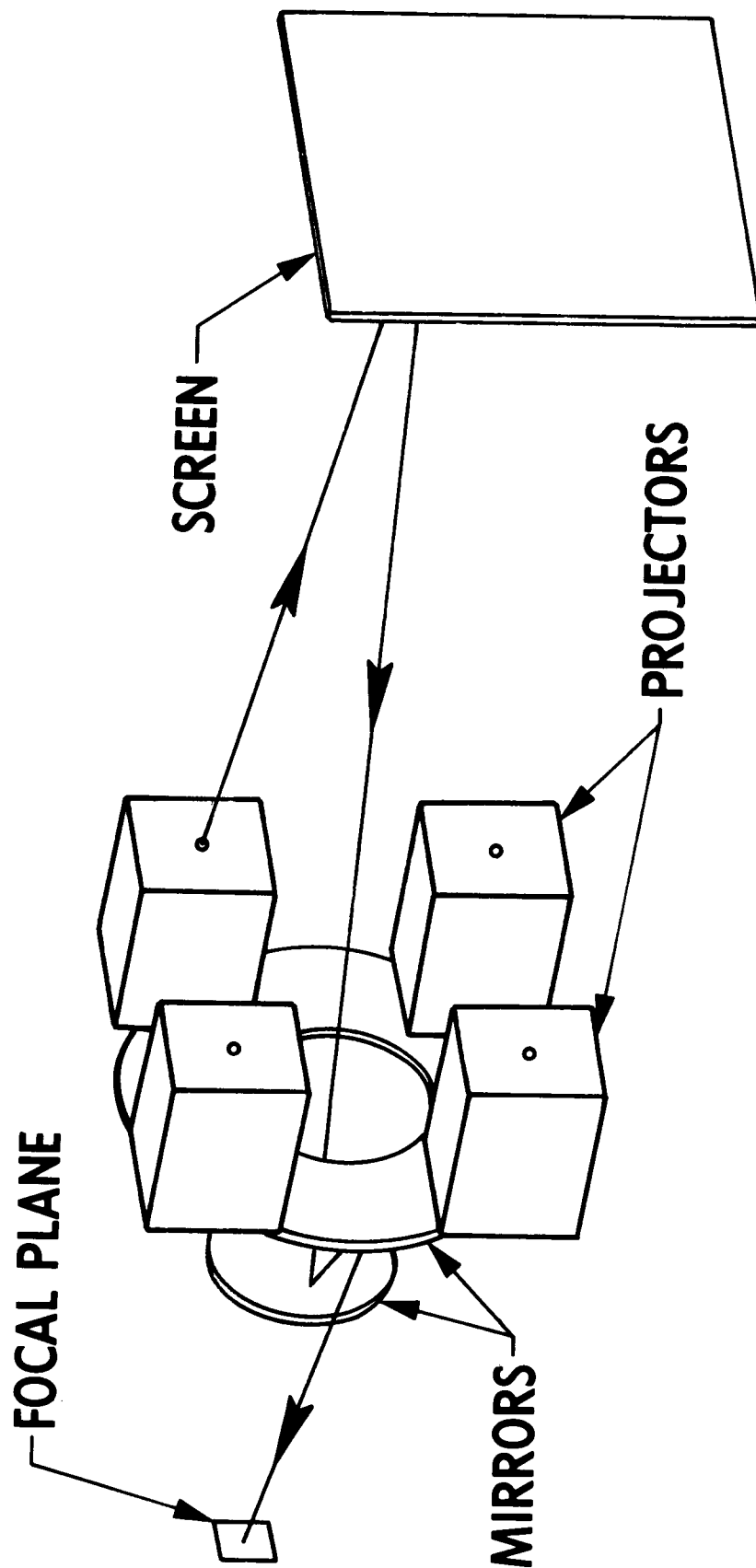


Figure 7. Target generator follow on

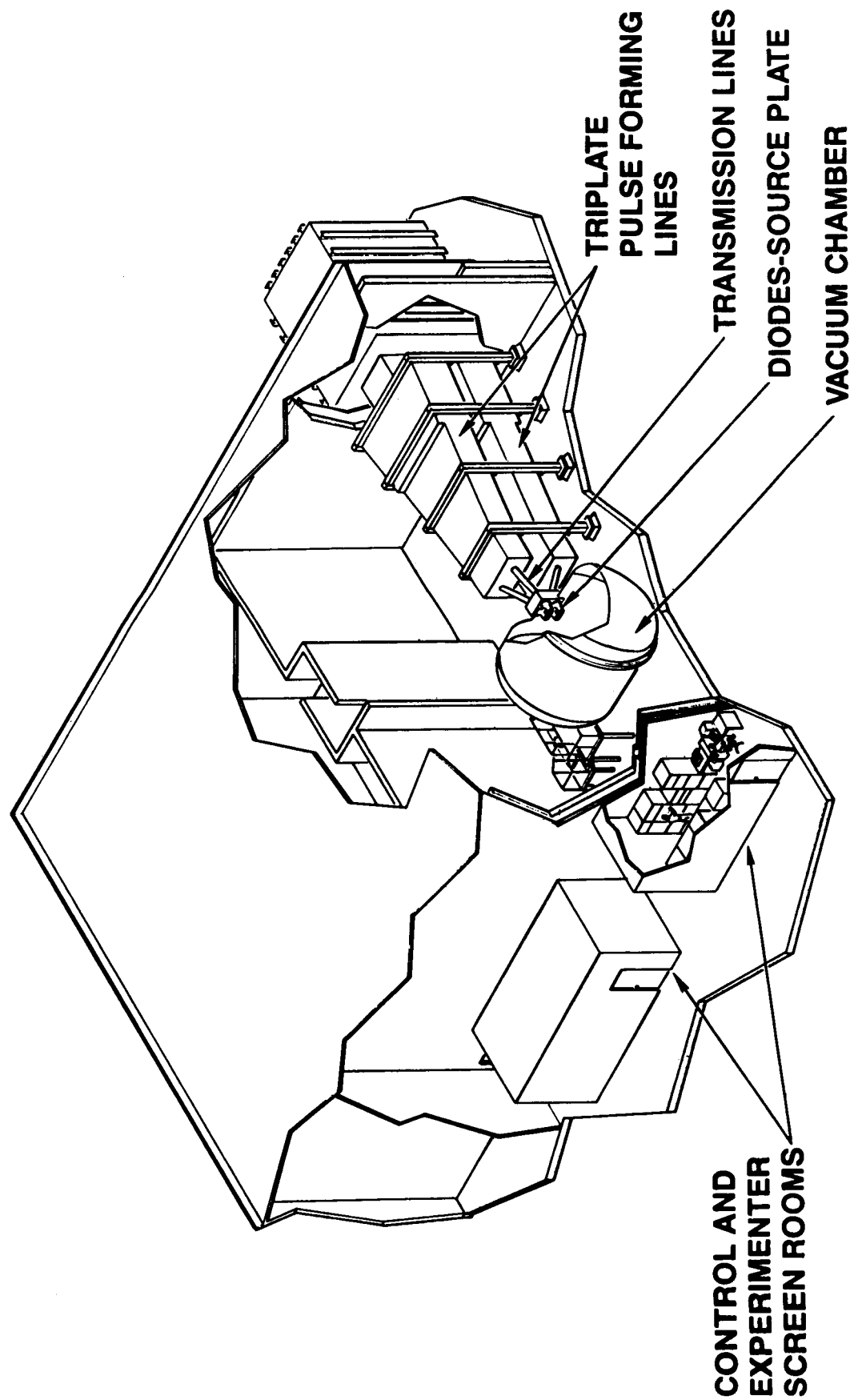


Figure 8. AEDEC pilot x-ray facility

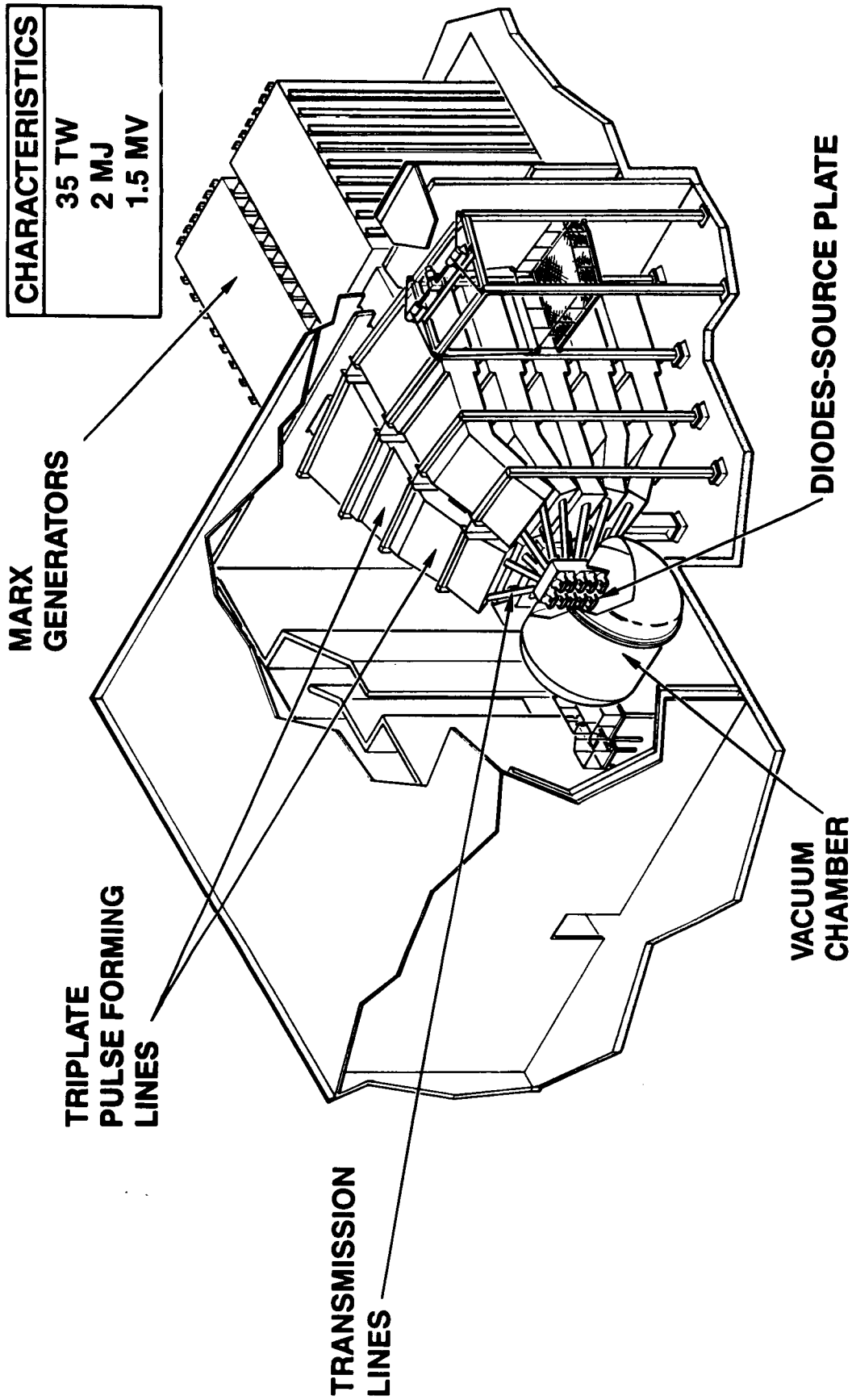


Figure 9. AEDC modular x-ray facility

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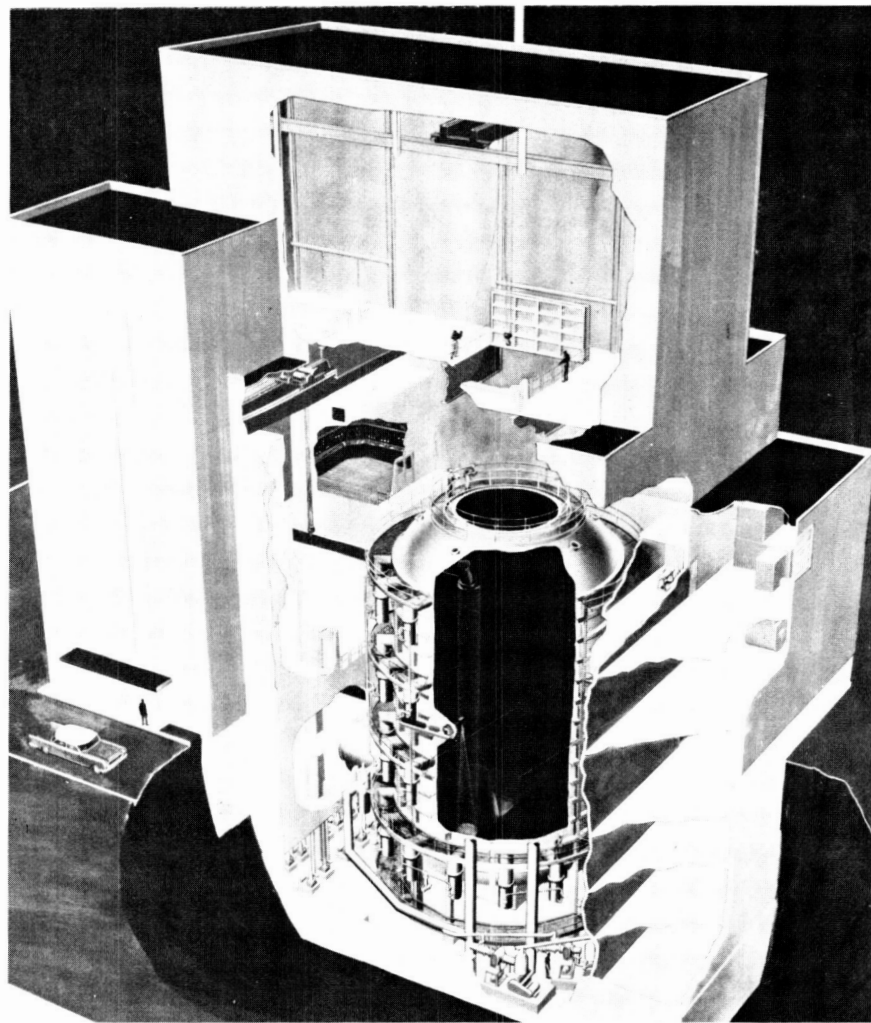


Figure 10. Small sensor off-axis-rejection testing in AEDC aerospace chamber mark I

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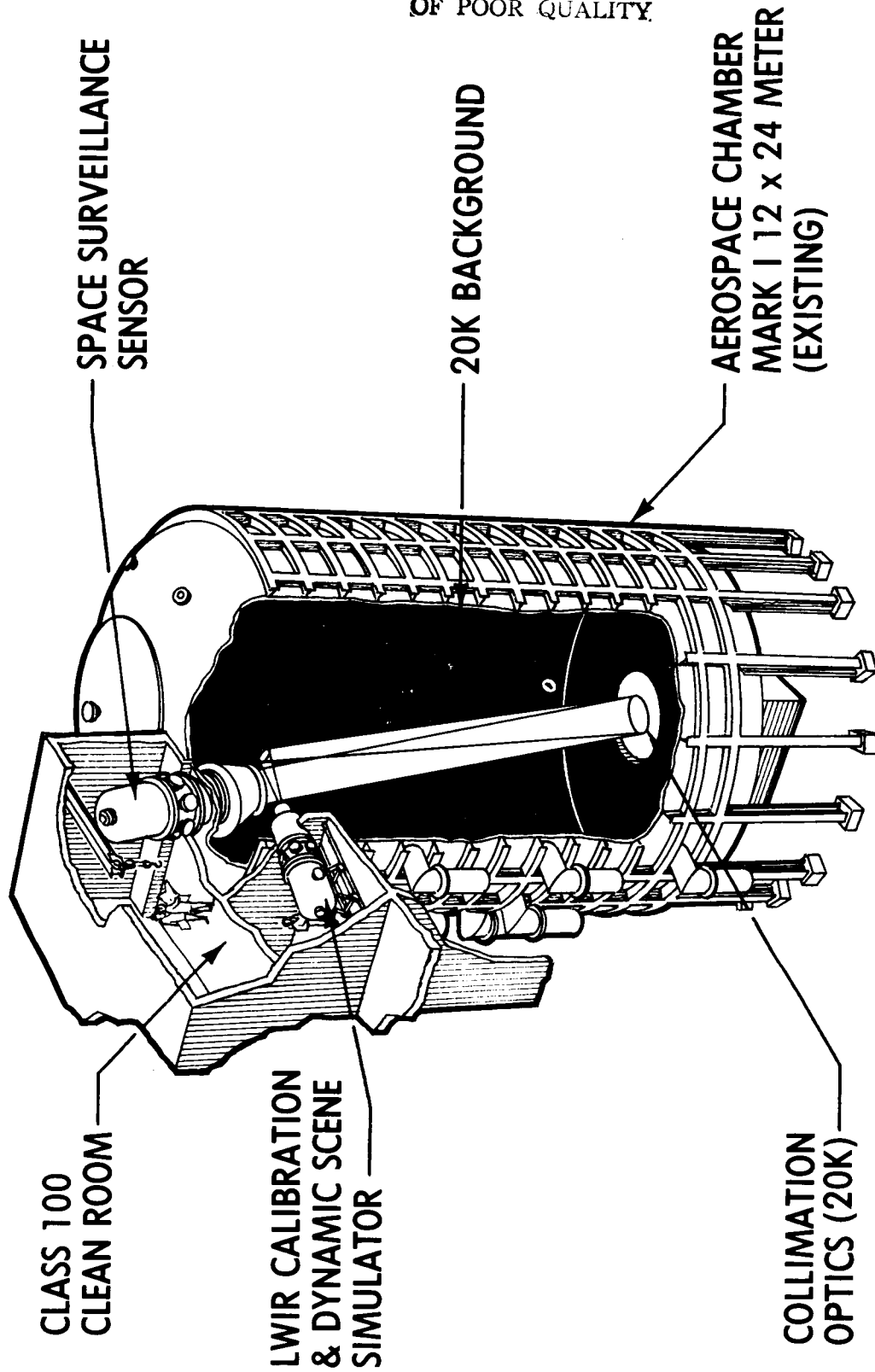
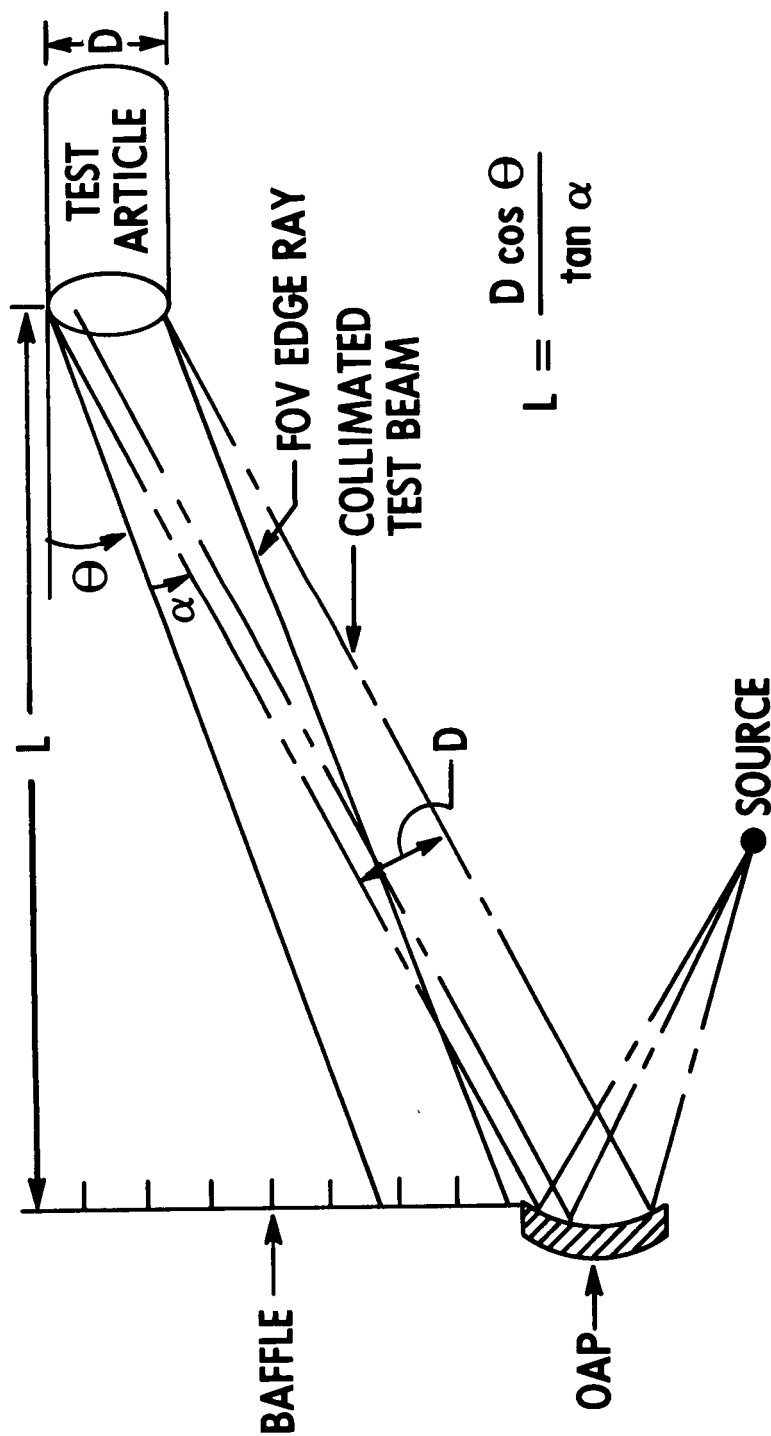
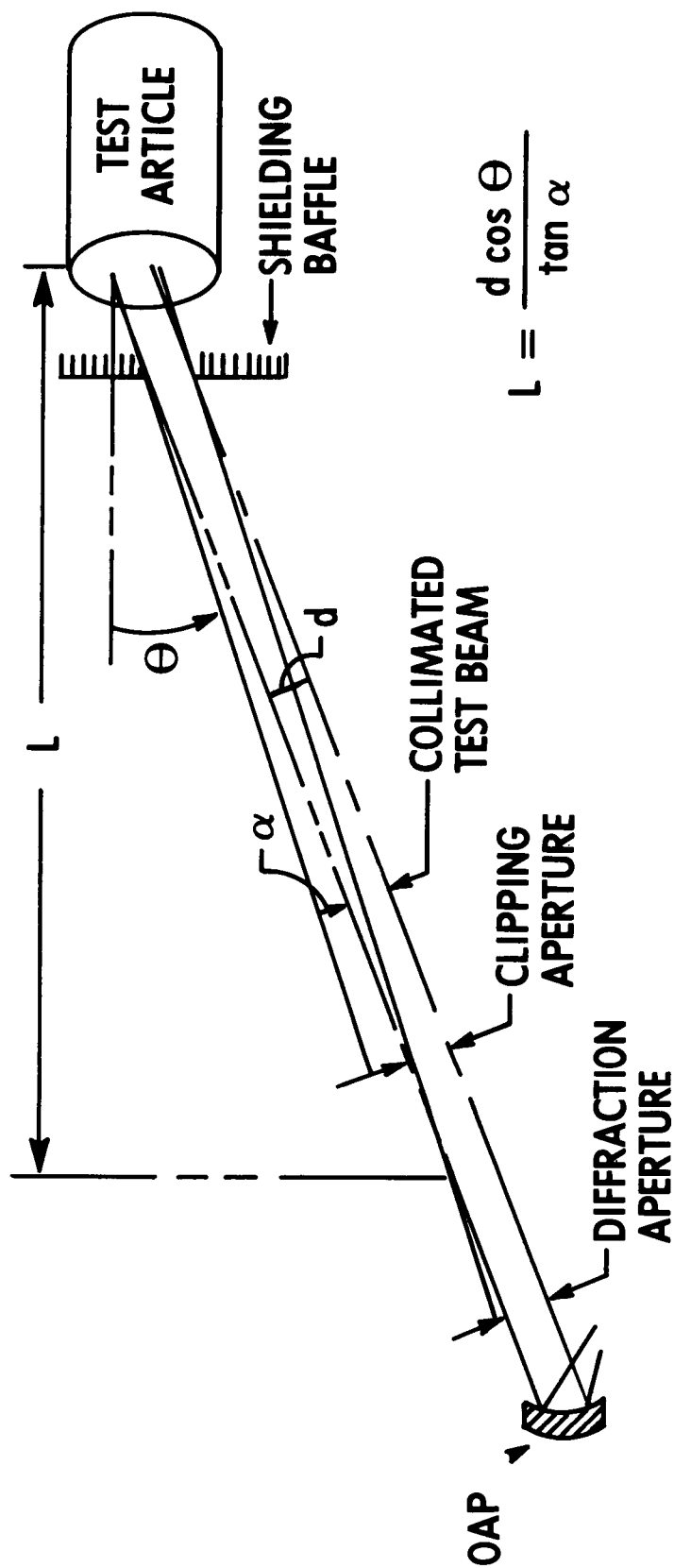


Figure 11. Concept for 1-meter class sensor testing in AEDC aerospace chamber mark I



- **FACILITY LENGTH IS PROPORTIONAL TO TEST ARTICLE DIAMETER FOR FULL APERTURE OR SUBAPERTURE TEST BEAMS**

Figure 12. Traditional off-axis-rejection geometry



● FACILITY LENGTH PROPORTIONAL TO TEST BEAM DIAMETER

Figure 13. Alternate off-axis-rejection geometry

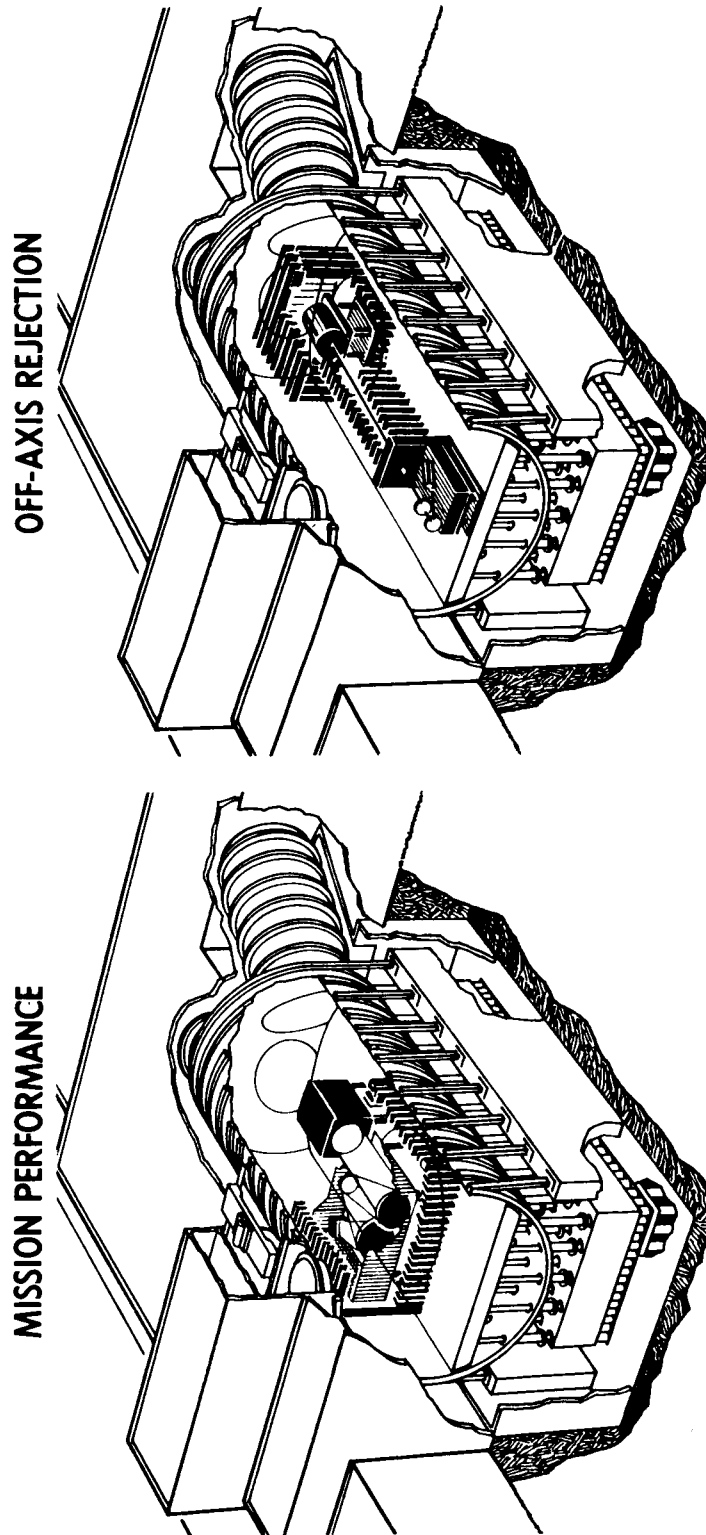


Figure 14. 2- to 3-meter sensor testing in AEDC space facility